Investigation of Agent or Multi-agent Technologies in E-Commerce Systems

Ghalib Alshammri[†]

[†]Faculty of Computer Science, King Saud University (College of Teaching), Riyadh, Kingdom of Saudi Arabia

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1. Agent Technology

Ubiquitous computing has become an integral part of human life. The growth of the Internet has redefined the role of computers and the way they are used as means to interaction in the world. Due to this change the essence of computation has shifted from standard calculation and processing to delegation and continuous interaction (Fasli, chp1), hence the need for new models which reflect this change is required. These models are required to be autonomous, learning, reactive and interactive. This ensures that all delegated goals and processes are achieved with minimum resources. A mobile agent is an autonomous entity that has the ability to migrate in a heterogeneous network and resume its executions. Agents can reduce network traffic, improve utilisation of resources, execute autonomously, be dynamic and fault tolerant (Fasli, chp 11). It is a piece of software/hardware that acts on behalf of users. Russell defines an agent as "anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors" (Russell and Norvig, 2003). It uses practical reasoning based on information received about the world and its defined goals will enable it to make decisions until the goal is reached. Furthermore multi-agent systems are a collection of single agents that are used to communicate and interact with one another to solve problems that have been delegated by users. Agent technology differs from standard software due to the autonomy it undertakes to achieve its user's goals. This is done through actively learning based on the situation that arises in the network. Agent technology can be used across many fields; these include process control, operations management, information management, and education.

In a single agent environment there is one agent that is used to perform all decisions; while multi-agent systems use more than one agent to communicate between one another to obtain a suitable decision. Agents in a multi-agent environment must take into consideration the other agents present such that interference is minimised and coordination maximised. The knowledge and skills are distributed among agents. Multi-agent systems are used when a single agent cannot solve the complex problem. In turn the use of multi-agent systems in comparison to single agent systems is the reliability, maintainability and reusability of agents.

The interaction between agents is controlled by following rules set out in an interaction protocol. In this instance agents must be able to reach compromise, resolve conflicts, and allocate resources by agreement (Fasli, chp8). A negotiation situation is generally characterised by three elements; firstly a negotiation set is provided which can be used as a collection of possible offers that an agent can make. Secondly the specific protocol that is used controls the agent's interaction and finally the strategies that have been defined for the agent to use; these are private and may take into account other agent strategies.

A negotiation protocol is separated into admission rules, interaction rules, validity rules, outcome determination, withdrawal rules, termination, and commitment rules. Finally the chosen protocol is dependent on agent system itself, this includes the number of attributes that an agent is to have, the number of agents present and the number of goods.

Agent architectures can be based on logic, reaction, belief-desire-intention, or hybrid. Logic-based agents utilises mathematical equations to model the surrounding environment and the rules with which it makes its decisions. A disadvantage of logic-based agents is the difficulty with which to model the surrounding environment in a form that is suitable to allow the agent to perform the necessary reasoning, planning and action in time. Reactive architectures utilise a direct link to the environment by building the representation into the sensory capabilities of the agent. An advantage of using reactive agent architectures is that complexity is reduced due to the removal of an internal representation of the surrounding environment. However the planning capability of the agent is reduced as it requires large amounts of information to determine the current state. Belief-desire-intention architecture is broken into three sections; beliefs are the agent's information about the world, desires is the motivation and possible options of the

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agent and intentions are the agent's commitment. The BDI components can be seen below.

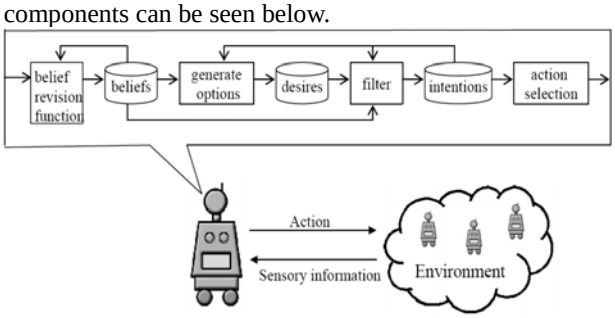

Figure 1: Beliefs-Desires-Intentions architectural components (Fasli, chp2).

Hybrid architectures combine reactive and deliberative components to form interacting layers with each layers performing different reasoning. The layering that exists for hybrid is horizontal and vertical layering. In horizontal layering each layer can act as an independent agent such that for *n* different behaviours *n* layers are implemented, for example;

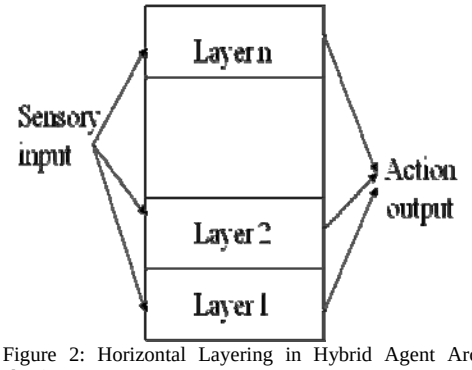

Figure 2: Horizontal Layering in Hybrid Agent Architecture (Fasli, chp2).

Vertical layering can be seen as follows;

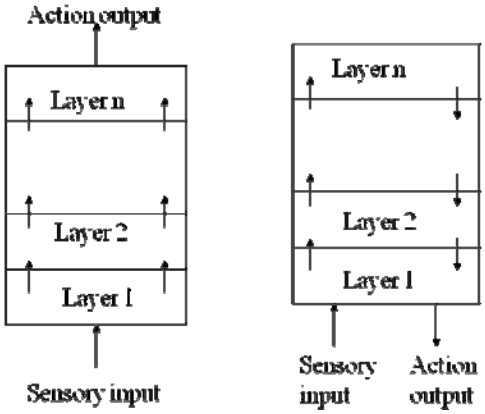

Figure 3: Vertical Layering for Agent Architectures (Fasli, chp2).

The advantage of vertical layering is a reduction in the complexity of the system. The number of interactions is reduced to $m^2(n-1)$ interactions, in comparison to m^n interactions for a horizontal system.

2. Economic Implications of Agent Technology in E-Commerce Systems

Agent technology in e-commerce has many uses, such as providing users with the ability to obtain and compare products, vendors, and services. Allows for the participation in electronic markets with the ability to negotiate terms and conditions or transactions; this also includes the completion of such transactions on behalf of users. Monitor, retrieve, and deliver e-services from information gathering. In providing these uses, agent technology automates e-commerce transactions such that organisations can take advantage of opportunities as they arise no matter the time of day. For example Vulkan presents the economic implications that agent technology will provide to e-commerce (Valkin, 1999). In this instance he states that the $1.5 billion a year e-commerce market is likely to increase sharply due to the introduction of software agents. The author raises three research categories in which e-commerce can be addressed by economist; these include:

- Designing markets for interaction between agents, such as the development of multi-agent interaction protocols and negotiating agents.
- Impact analysis on markets due to the use of agents.
- Analysis of the interaction between users and agents.

The author states that the design of automated markets should be approached no different to that of an ordinary market. This is due to the fact that companies who establish online markets have a central aim of designing the market to maximise their profits through efficiency and competitiveness. Hence interaction protocols for multi-agent systems must be chosen on the same criterion, to maximise profit. However a potential risk to agents in the marketplace is that e-commerce sites may block their sites from being interrogated by agents, this can cause potential problems for users that rely on these agents. The second category in which the author suggests is purely an economic impact; this is due to the fact that agent technology provides added advantage to the consumer. Whether it is providing comparative prices of airline tickets or merely conducting an analysis of competitor prices in comparison to your own prices. These activities can be undertaken by the agent as based on the user preferences provided. In this instance agent technology

will definitely lower search costs not only for consumers but also for suppliers who attempt to wish to find out the competitor's price. This will allow competing suppliers to initiate pricing strategies to increase competition. The third category that is raised by the author highlights the importance of a framework which allows users to build the necessary trust to allow the agent technology to act in the best interest of the user, especially financial decisions. The user must be able to express the primary objective that they wish to achieve explicitly to ensure the agent can reach that objective. This can prove difficult as many users run into problems when attempting to decide what it is they actually want. The problem of building accurate preferences and utility functions for agents that can accurately decide on previous user behaviour will fall on the designers of agent technology. It can be seen from this example that agent technology has provided strategic economic gains to companies that can utilise the technology.

3. Uses of Agent Technology in E-Commerce

As mentioned earlier agent technology provides users the ability to perform many tasks which are time consuming and laborious. Uses of agent technology in the field of e-commerce include; asset management, buying and selling agents, tourism-based agents, and contract modelling agents.

Wan et al proposes a three-tier multi-agent architecture that can be used as an asset management consultant (Wan, 2004). By proposing a customer relationship management (CRM) service system, enterprises can improve efficiency and quality of service to potential clients. The main focus of this implementation is to accommodate for financial markets and the need for quick response to any market changes. The system is separated into three levels; the first level is designed to provide customised services for different clients. The second level of the architecture is designed to analyse information and provide level one with financial knowledge. The third level of the agent is to organise raw data into information that is suitable to be analysed by the second level. The main advantage of such a system is that the agent technology can be deployed for 24 hours a day and not be constrained physically similar to actual financial consultants. By utilising a multi-agent approach this system has the capability to servicing more than one customer at any given time. This is due to the fact that each agent in the system is assigned to a customer. Hence the first layer is customisable as it is based on the client's behaviour and trading techniques, obtaining this information the agent can then learn what the client needs based on the specified objectives. Once customer behaviours and objectives have been determined the system is required to analyse each commodity that the client trades or is interested in, this ensures that any decisions or recommendations given by the agent are as close to the clients objectives as possible. The final level ensures that real-time financial data is packaged in such a way that the analysis module of the architecture can easily analyse the provide information and make the recommended information based on the provided objectives. Such a system is advantageous in the financial market as it allows the client to monitor all changes and react in a timely manner. However for this system to be effective the analysis module must be able to decipher incoming information quickly to ensure the clients reaction time is reduced to a minimum, especially in volatile financial times.

Agents can not only be used to assist on financial markets, but can also be used as buying and selling agents. Maes and Guttman, provide an insight into the advantages that automated agents provide when users are buying and selling (Maes and Guttman, 1999). Such as an automated process of using agents to monitor paper usage in a company and when stock is low use a buying agent to automatically purchase the required quantity. The model that is used by the authors comes from the consumer buying behaviour model (CBB). This model is focused on actions and decisions based in a buying and selling environment, such as a retail market. To ensure that a solid buying behaviour is captured; models such as the Nicosia model, Engel-Black-Well model share the following six fundamental buying stages.

- Need identification – which characterises the buyer identifying a required need such as a product or service.
- Product brokering – involves the process of information retrieval regarding this unmet need. In this instance information is gathered based on the user criteria and involves producing a set of products that can be included for consideration.
- Merchant brokering – determines who to buy from. This is done by analysing merchant-specific information such as price, availability, warranty, etc, combined with the product set obtained from the product-brokering.
- Negotiation – sets out the terms of agreement that is to be undertaken between the client and the service provider. Negotiation varies in complexity depending on the market, for example standard retail outlets have a fixed price for merchandise and hence negotiation is limited however markets such automobile purchases, negotiations plays an integral role in achieving the best possible price.

- Purchase and delivery – indicates that the negotiation stage has been completed, and that the product has been bought.

- Product service and evaluation – involves post purchase such customer service and evaluation of customer satisfaction of the overall buying decision.

In this instance the six mentioned points represent estimates of complex buying behaviours. Whereby the major decisions are delegated to the agent based on a buying criteria set out by the user. In doing so buying and selling agents reduces the amount of time that consumers must spend searching, analysing and comparing products and services before a product or service is bought.
Agent technology has also been proposed to be used in e-commerce as a means to help in the tourism markets. Dikenelli et al proposes an agent-mediated e-commerce framework that is focused on assisting in tourism related products and services. In this instance an agent-mediated system is developed to automate the hotel reservation process (Dikenelli). The authors propose that the framework is split into two groups. The first group defines generic agent behaviour and functionality, these include:

- The development of Foundation for Intelligent Physical Agents (FIPA) compliant framework.

- Introduce web-based security capability and a generic reusable functionality. This ensures that any communication such as negotiations undertaken via the agent can be done in a secure manner contributing to the foundation of the trust model.

- Utilise XML to model the agent framework.

The second group for this framework is domain specific in this instance tourism in the Aegean, these include:

- A complete definition of tourism activities in the Aegean region.

- A suitable definition of a trust model for secure tourism marketplace. In this instance a suitable framework musty be developed which incorporates the certification and security policies for the tourism industry in the Aegean region. This must incorporate the necessary laws that are currently implemented in the region.

- Develop a method of integrating the hotel reservation system currently present in the region with the agent platform.

In this instance both customers and travel agents benefit from such a system due to the fact that negotiation strategies will not only depend on price but also room availability, facilities, etc. To achieve a separation between generic agent behaviour and domain-specific behaviours, a multi-layered framework is proposed. This is advantageous as the generic functionality that is required for the agent can be kept together and reused in other agent frameworks. The proposed framework includes the following layers; communication, conversation and execution, reusable actions, and agent and domain specific layer. The communication layer provides the necessary functionality to allow the agent to communicate with FIPA. The conversation and execution layer contains the interaction protocols that will allow the agent to request, query, and contract. As the name suggests the reusable layer contains the generic functionality that all agent can use, for example registration to agent management services. The final layer contains specific information related to the agent's domain, in this instance tourism, for example searching functionality to find available rooms and hotel vacancies.
Due to the presence of multiple agents in the system a social order must be imposed on each agent, this ensures that cooperation between the agents is maintained and a coherent behaviour is achieved. Gateau et al proposes a contract model that is used in agent-mediated ecommerce systems (Gateau, 2004). In this instance the proposed model controls each agent through firstly getting each agent to publish its request services with a "Matchmaker" service. This matchmaker service identifies the requested service of the agent with the services provided. Secondly a "Notary" service used to check the contract after negotiation has taken place, this ensures that agents can work with one another. Thirdly an "Arbitrator" service supervises all active contracts. The arbitrator ensures that agent fulfil all commitments or enforce sanctions by controlling the execution of the contract. Finally a "Reputation" service is applied to rank how trustworthy each agent is. This reputation value is assign by the by the arbitrator and is based on the agent's ability to execute contracts. Having such a process in place ensures that multi-agent interactions are secure whereby trust is built upon through the agent's completion reputation. This ensures that trust models in agent technologies are improved to a point where users can safely delegate higher priority decisions to agents.

4. Conclusion

Due to the rapid growth of the Internet, the need for streamlining processes in e-commerce has become vital. Agent technology has been the response to this need. It has provided opportunities in removing the time-consuming aspects of e-commerce such as searching and information gathering for specific products and

services. This has been achieved by modelling consumer behaviour in many different aspects of e-commerce. This includes purchasing and negotiation or simple searching and product comparisons. Furthermore the introduction of agent technology in ecommerce systems has provided significant economic advantages such that search costs are reduced to a minimum and increased competiveness through the ability to monitor competitors and react accordingly.

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Ghalib Alshammri received the master degree (Master of Computer Science “Major: Intelligent Systems”) from the University of Wollongong in 2009 and he is a PhD student at the University of Newcastle. Moreover, he is a assistant teacher at King Saud University (College of Teaching) – Faculty of Computer Science.